ASTM INTERNATIONAL
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Final Program

2002 Johnson Conference: A Review of Asbestos Monitoring Methods and Results for The New York World Trade Center, Libby Vermiculite, and Fibrous Talc

July 21-25, 2002
Johnson State College
Johnson, Vermont

Sponsored by ASTM Committee D22 on Sampling and Analysis of Atmospheres

Contents

WELCOME!

July 21, 2002

Dear ASTM Johnson Conference Attendees:

On behalf of ASTM it is our pleasure to welcome you to the **2002 Johnson Conference** on **A Review of Asbestos Monitoring Methods and Results for The New York World Trade Center, Libby Vermiculite, and Fibrous Talc.**

This conference will focus on monitoring methods, data, and interpretation of results associated with the World Trade Center, Libby vermiculite, and fibrous talc. Other recent developments and topics on asbestos monitoring methods will also be presented. Presentations will include information on what we think we know, what we think we understand, and what we need or would like to know about asbestos exposure associated with these sources.

The primary purpose of the conference will be to present and discuss data from asbestos monitoring associated with the World Trade Center, vermiculite mined and processed from Libby, and fibrous talc. Asbestos monitoring strategies, analytical methods, data interpretation, and quality assurance procedures will be discussed. Other developments in asbestos monitoring techniques will also be discussed.

Presentations made at this conference will contain the most current data and conclusions. **Citations of the work presented may be made only with the written permission of the authors.** This procedure encourages the presentation of the most recent work in the field and allows discussion of new ideas and possible interpretations of the data.

An essential part of this review is the participation and perspectives of the attendees at this conference. It is our hope that all speakers and attendees will attend all sessions of the conference and join in the dialog. We want this conference to be a workshop at which we put our heads together for the benefit of all. Each speaker is allowed two-thirds of their allotted time for making their presentation. The remaining third is set aside for discussion. **Please hold all questions for the discussion period.** This process will provide us all with the opportunity to pose questions directly to the presenter, express our opinions and (hopefully) to promote understanding. Please join in the question and answer period and become a part of the dialog.

HAVE A GREAT JOHNSON CONFERENCE!

Mike Beard and Harry Rook, ASTM Conference Co-Chairs

George Luciw, ASTM Staff Manager

Dorothy Fitzpatrick, ASTM Symposia Manager

Wine and Cheese Reception

An informal wine and cheese reception to welcome participants will be held on Sunday, July 21 from 7:00 p.m. to 9:00 p.m. in Sterns Dining Hall. Please stop by and meet your colleagues

Continuing Education Units (CEUs)

Conference attendees interested in receiving 2.45 Continuing Education Units should complete a CEU application form at the adjournment of the conference, then submit it to the ASTM staff member on site. A certificate will be sent to the attendee approximately 4 to 6 weeks after the conference.

The conference has also been approved by the **American Board of Industrial Hygiene** and 3.5 Industrial Hygiene CM Points will be awarded to those who attend the conference (0.5 points per session). The approval number is 02-1895.

Cell Phone Policy

PLEASE! Turn your cell phone OFF when entering the conference auditorium.

There are thirty-six presentations prepared by investigators from several countries. There are also attendees who have traveled here to hear these presentations. Cell phones ringing during the presentation interrupt the speaker and attendees. Even when cell phones are in a "silent" or "vibrate" mode, a presentation may be interrupted by someone answering a call or getting up to leave the room. As a courtesy to the speaker and the attendees, **please turn off your cell phone when you enter the auditorium!**

NIST Workshop

Addressing Continuing Measurement Problems for Fibrous Talc

Wednesday Afternoon, 1:30 - 3:00 PM

Moderator: J. R. Verkouteren, National Institute of Standards and Technology, Gaithersburg, MD

NIST was petitioned by industry in late 2001 to prepare a standard for fibrous talc to address continuing measurement problems. In response to the petition, a workshop will be held in conjunction with the 2002 ASTM Johnson conference "A Review of Asbestos Monitoring Methods and Results for the New York World Trade Center, Libby Vermiculite, and Fibrous Talc". The workshop is open to anyone who wishes to attend. We would like industry, regulatory, and technical representatives to attend the workshop to discuss possible actions NIST, ASTM, and other government agencies might take concerning measurement issues for fibrous talc. The workshop will follow the Johnson conference technical presentations on fibrous talc, and therefore the discussions can concentrate on the possible actions.

One plan proposed by NIST is to prepare an educational document summarizing the current state of knowledge on measurements of fibrous talc for dissemination to NVLAP laboratories. The proposal would include the opportunity for technical contributions from the community in the preparation and review of such a document. Alternative plans are solicited from the audience. Following the workshop, NIST will decide on a specific plan consistent with the goals and the available resources, and will communicate this information to participants of the workshop.

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July 21-25, 2002
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CONFERENCE COMMITTEE

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	Dr. Harry L. Rook National Institute of Standards & Technology (Retired) Moretown, Vermont
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James S. Webber
N. Y. State Department of Health
Albany, NY

Jennifer R. Verkouteren
National Institute of Standards and Technology
Gaithersburg, Maryland

MONDAY, JULY 22, 2002

7:30 A.M. REGISTRATION [Bentley Hall Auditorium]

8:30 A.M.
Welcome and Opening Remarks
Michael E. Beard, and Harry L. Rook, Conference Chairmen

SESSION 1: MONITORING AT THE WORLD TRADE CENTER

Monday Morning Session Chair:	Roger A. Morse Morse Associates Poestenkill, NY

8:45 A.M.
Initial Health Hazard Evaluation - World Trade Center, 2001: Lessons Learned
R. H. Granger, HP Environmental, Inc., Herndon, Virginia

9:15 A.M.
Fireproofing and Asbestos in the World Trade Center
R. A. Morse, Morse Associates, Poestenkill, NY

9:45 A.M.
Asbestos in Settled Dust Concentrations Outdoors in New York City Before September 11, 2001
W. M. Ewing, Compass Environmental, Inc., Kennesaw, GA

10:15 A.M. BREAK

10:30 A.M.
Characterization of Settled Dust Resulting from the World Trade Center Tragedy September 11, 2001
J. R. Millette, MVA, Inc., Norcross, GA

11:00 A.M.
Characterization of Particulate Found in Apartments after Destruction of the World Trade Center
E. J. Chatfield, Chatfield Technical Consulting, Mississauga, ONT, Canada, and
J. R. Kominsky, Environmental Quality Management, Inc., Cincinnati, OH

11:30 A.M.
Asbestos in Street-Water Run-Off And Roof Tanks near the World Trade Center Disaster
J. S. Webber and L. Carhart, New York State Department of Health, Albany, NY

12:00 Noon
Discussion of World Trade Center Monitoring

12:30 P.M. CONFERENCE ADJOURNS FOR THE MORNING

SESSION 2: MONITORING AT THE WORLD TRADE CENTER

Monday Evening Session Chair: Thomas R. McKee
Scientific Laboratories, Inc,
Midlothian, VA

7:00 P.M.
Inorganic Geochemistry of Dusts Deposited in Lower Manhattan after the September 11, 2001, World Trade Center Collapse
Geoffrey S. Plumlee, US Geological Survey, Denver, CO

7:30 P.M.
The Protocol for Assessing Asbestos-Related Risk: A Status Report
D. W. Berman, Aeolus, Inc., Albany, CA

8:00 P.M.
Mineralogical and Geochemical Function on the Health Effects of Asbestos Mineral Dusts: Insights from a Comparison of 24 Asbestos Toxicological Standards
T. L. Ziegler, P.J. Lamothe, G. P. Meeker, I. K. Brownfield, H. Lowers, T. K. Hinkley, G. S. Plumee, M. L. Witten, US Geological Survey, Denver, Co, And N. Nsun, University of Arizona, Tucson, AZ

8:30 P.M. BREAK

8:45 P.M.
Health Testing at Ground Zero, New York City
C. E. Gilbert. Enviroscience Consultants Inc., Ronkonkoma, NY 11779

9:15 P.M.
Microanalysis and Materials Characterization of Dusts Generated by the World Trade Center Collapse
G. P. Meeker, S. J. Sutley, G. A. Swayze, T. M. Hoefen, R. N. Clark, I. K. Brownfield, And C. Gent, US Geological Survey, Denver, CO

9:45 P.M.
Discussion: What Have We Learned from the World Trade Center Disaster?

10:30 P.M. CONFERENCE ADJOURNS FOR THE DAY

10:30 P.M. RECEPTION – CASH BAR [Base Lodge]

TUESDAY, JULY 23, 2002
[Bentley Hall Auditorium]

8:30 A.M.
Welcome and Opening Remarks
Michael E. Beard, and Harry L. Rook, Conference Chairmen

SESSION 3: MONITORING LIBBY VERMICULITE

Tuesday Morning Session Chair: James S. Webber
New York State Department Of Health,
Albany, NY

8:45 A.M.
Libby...A Historical Perspective
W. M. Ewing, Compass Environmental, Inc., Kennesaw, GA

9:15 A.M.
Sampling and Analysis of Vermiculite-Containing Consumer Products for Asbestos Contamination
L. J. Phillips, D. Nelson, J. Buchert, S. Schwartz, Versar, Inc., Springfield, VA, and T. Simons, USEPA. Washington, DC

9:45 A.M.
Review of EPA Studies on Consumer Garden Products that Contain Vermiculite
E. J. Chatfield, Chatfield Technical Consulting, Mississauga, ONT, Canada

10:15 A.M. BREAK

10:30 A.M.
Strategies for Determination of Asbestos in Vermiculite
E. J. Chatfield, Chatfield Technical Consulting, Mississauga, ONT, Canada

11:00 A.M.
Optical and Morphological Characterizations of Amphibole and Amphibole-Asbestos Collected from the Former Vermiculite Mine near Libby, Montana, U.S.A.
M. E. Gunter, B.R. Bandli, and B.M. Brown, Department of Geological Sciences, University of Idaho, Moscow, ID

11:30 A.M.
Analytical Methods and Quality Assurance in Vermiculite Testing
J. Addison, John Addison Consultancy, Cottingham, East Yorkshire, UK

12:00 Noon
Discussion of vermiculite issues

12:30 P.M. CONFERENCE ADJOURNS FOR THE MORNING

SESSION 4: ANALYSIS OF FIBROUS TALC

Tuesday Evening Session Chair:	Jennifer R. Verkouteren National Institute of Standards and Technology Gaithersburg, MD

7:00 P.M.
Analysis of Crayons for Asbestos and other Fibrous Materials
O. S. Crankshaw, M. E. Beard, And J. T. Ennis, Research Triangle Institute, Research Triangle Park, NC

7:30 P.M.
Critical Issues in the Identification of Asbestos - Whatever the Mineral Species
R. J. Lee, D. Veblen, and D. Van Orden, RJ Lee Group, Inc., Monroeville, PA

8:00 P.M.
The Health Experience of Vanderbilt Talc
J. Kelse, R. T. Vanderbilt Co., Inc., Norwalk, CN

8:30 P.M. BREAK

8:45 P.M.
The Optical Properties and Chemical Composition of Fibrous Talc
W. Greenwood and A. G. Wylie, University of Maryland, College Park, MD

9:15 P.M.
Reconstructing a Century of Airborne Asbestos Concentrations in the Talc-Mining Region of New York State: Tales from the Muck
J. S. Webber, New York State Department of Health, Albany, NY

9:45 P.M.
Discussion of talc analysis

10:30 P.M. CONFERENCE ADJOURNS FOR THE DAY

10:30 P.M. RECEPTION – CASH BAR [Base Lodge]

WEDNESDAY, JULY 24, 2002
[Bentley Hall Auditorium]

8:30 A.M.
Welcome and Opening Remarks
Michael E. Beard and Harry L. Rook, Conference Chairmen

SESSION 5: ANALYSIS OF FIBROUS TALC

Wednesday Morning Session Chair: Robert L. Perkins
Research Triangle Institute (Retired)
Lillington, NC

8:45 A.M.
Geologic Origins of the "Transitional Fibers" in Fibrous Talc Deposits
B. S. Van Gosen and G. P. Meeker, US Geological Survey, Denver, CO

9:15 A.M.
Mineralogy and Experimental Animal Studies of Tremolitc Talc
G. L. Nord, C. W. Axlen, M. Ross, And R. P. Nolan, Brooklyn College of the City University of New York, Brooklyn, NY

9:45 A.M.
Analyzing Non-Asbestos Asbestiform Minerals
D. T. Crane, OSHA, Salt Lake City, UT

10:15 A.M. BREAK

10:30 A.M.
Limitations of Methods for Determination of Asbestos in Talc
E. J. Chatfield, Chatfield Technical Consulting, Mississauga, ONT, Canada

11:00 A.M.
Discussion of Talc Analysis

12:30 P.M. LUNCH

1:30 P.M. **SPECIAL SESSION**
NIST Workshop: Addressing Continuing Measurement Problems For Fibrous Talc
J. R. Verkouteren, National Institute of Standards and Technology, Gaithersburg, MD

3:00 P.M. CONFERENCE ADJOURNS FOR THE DAY (no evening session)

THURSDAY, JULY 25, 2002
[Bentley Hall Auditorium]

8:30 A.M.
Welcome and Opening Remarks
Michael E. Beard and Harry L. Rook, Conference Chairman

SESSION 6: ASBESTOS ANALYSIS – GENERAL TOPICS

Thursday Morning Session Chair:	Eric J. Chatfield Chatfield Technical Consulting, Mississauga ONT, Canada

8:45 A.M.
Optical Characteristics and Mineralogy of "Environmental" Amphibole Asbestos
J. R. Verkouteren, National Institute of Standards and Technology, Gaithersburg, MD and A. G. Wylie, University of Maryland, College Park, MD

9:15 A.M.
Tremolite Analysis of Chrysotile Containing Friction and Gasket/Packing Products
W. E. Longo, W. Egeland, R. Hatfield, R. Stapleton and J. Hubbard, Materials Analytical Services, Inc., Suwanee, GA

9:45 A.M.
Revisiting Refractive Index Measurements
P. M. Cooke, MICA, Chicago, IL

10:15 A.M. BREAK

10:30 A.M.
Asbestos Impurities in Olivines
G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield, UK

11:15 A.M.
An Assessment of the Airborne Release of Asbestos Fibres from Olivine Grits
G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield, UK

11:45 A.M.
Discussion

12:30 Noon LUNCH

SESSION 7: ASBESTOS ANALYSIS – GENERAL TOPICS

Thursday Evening Session Chair: Gregory P. Meeker
US Geological Survey
Denver, CO

7:00 P.M.
The Quality of Fiber Count Data of Slides with Relocatable Fields
T. W. S. Pang, Ryerson Polytechnic University, Toronto, ONT

7:30 P.M.
Enhancement of the Quality of Asbestos Fiber-Counting Analyses by Means of Certified Reference Slides
M. Harper, University of Alabama at Birmingham, Birmingham, AL, M. E. Beard, Research Triangle Institute, Research Triangle Park, NC, and J. H. Nelson, DataChem Laboratories, Salt Lake City, UT

8:00 P.M.
Polarized Light Microscopy: What Does It Mean for Asbestos?
D. W. Berman, Aeolus, Inc., Albany CA

8:30 P.M. BREAK

8:45 P.M.
The European Method for Measuring Asbestos in Bulk Materials
G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield, UK

9:15 P.M.
A PLM Method for Quantitative Analysis of Amphibole Asbestos in Bulk Materials at 0.01 Weight %
J. R. Verkouteren, National Institute of Standards and Technology, Gaithersburg, MD, and A. G. Wylie, University of Maryland, College Park, MD

9:45 P.M.
Discussion – Conference Wrap-Up

10:30 P.M. CONFERENCE ADJOURNS

FRIDAY, JULY 26, 2002

8:30 A.M.
ASTM Committee D22 Standards Development Meeting

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ABSTRACTS
(in order of presentation)

Initial Health Hazard Evaluation - World Trade Center, 2001: Lessons Learned

R. Hugh Granger, Ph.D., CIH, HP Environmental, Inc., Herndon, Virginia

Rarely is a professional presented with an opportunity to significantly contribute to society and make a difference. For some who practice in the arena of Public Health such an opportunity came on a day known as 9/11 and in a place forever branded as "ground zero". This presentation will critically review one component of the public health response following the collapse of the WTC buildings and make the first incision in a scientific postmortem wherein we examine our performance as professionals.

The focal point of this presentation is the preliminary health hazard evaluation conducted nine days after the collapse of the WTC buildings. For context the presentation will describe the site condition and the unique population at risk, detail the initial risk communication and public health pronouncements, and characterize the structure of the initial investigation. Methods and data will be presented and follow-up work will be described. The emphasis of the presentation, however, will be on lessons learned. The presentation will highlight the importance of knowing core assumptions upon which methods, standards and criteria are based, recognizing when these assumptions are violated, and how such violations can affect conclusions. The axioms of health risk communication will be reviewed and how deviation from these principles can result in confusion and disproportionate apprehension by the public. In conclusion, the presentation will describe the disorienting environment produced by a major catastrophic event such as 9/11 and the illusion it can create, that long held standards of practice must be abandoned – an illusion that will certainly fade with the smoke from the WTC fires.

Fireproofing And Asbestos In The World Trade Center

Roger A. Morse, Morse Associates, Poestenkill, NY

Asbestos-containing fireproofing was used in the World Trade Center. The exact locations were determined by the requirements of the building and by the political decision to change to a non-asbestos formulation while the buildings were being built. This session will describe the design and construction of the World Trade Center towers and the locations of asbestos-containing fireproofing. The possible scenarios that could have lead to the collapse will be discussed. The author observed deficiencies in the fireproofing during a decade of inspections in the buildings. These deficiencies will be described and photographic documentation presented. When fireproofing formulations changed in the early 1970's the new formulations were not always subjected to full-scale fire tests. To make matters worse there were no ASTM field quality assurance tests for fireproofing at the time of application in the WTC. Had these tests been in place at the time that the WTC was constructed they would easily have discovered the deficiencies in the fireproofing application. This leads to a more generalized concern about the adequacy of fireproofing in buildings between the time that asbestos was removed from fireproofing formulations to the time that the ASTM standard test methods were routinely used.

Asbestos In Settled Dust Concentrations Outdoors In New York City Before September 11, 2001

William M. Ewing, CIH, Technical Director, Compass Environmental, Inc., 1751 McCollum Parkway, Kennesaw, GA 30144

Surface dust sampling in Manhattan during the late 1980's found an average of 5100 asbestos structures per square centimeter (s/cm^2) outdoors. The 79 samples were taken from window ledges, building facades, and rooftops. Horizontal surfaces were generally higher than vertical surfaces, and the concentrations tended to diminish based on the height of the sampling location. Chrysotile was the form of asbestos found in any significant quantity. Surface dust samples reported taken on May 25, 2000 outside of the World Trade Center complex found an average of 2500 s/cm^2 at ground level in 9 samples by indirect TEM preparation, and no structures reported by direct preparation (<45 s/cm^2). Area and personal air samples (N=9) reported taken outdoors at the World Trade Center complex on May 25, 2000 found 0.14 s/cc by indirect TEM preparation, and essentially no fibers detected by direct TEM preparation. These data may be helpful in establishing cleanliness criteria following the World Trade Center collapse.

Characterization Of Settled Dust Resulting From The World Trade Center Tragedy September 11, 2001

J. R. Millette, MVA, Inc., Norcross, GA

A dust sample collected from Maiden Lane in New York City one month after the World Trade Center (WTC) tragedy of September 11, 2001 contained approximately 35 - 40% mineral wool, 5-10% cellulose, and less than 1% chrysotile asbestos. The remainder, non-fibrous components as analyzed by PLM, SEM and micro-FTIR, was composed chiefly of plaster, cement particles and combustion products. Some glass shards, wood fragments, soil minerals (quartz), metal flakes, vermiculite sheets and perlite were present. Based on a TEM analysis, the population of WTC Maiden Lane sample particles in the small size range (0.5 – 2.5 µm) was composed primarily of gypsum particles and cement fragments. Particles of the mineral wool (fibers and fragments) that made up a high percentage of the total WTC dust were present only at a trace level (<1%) in the 2.5 µm range. Seven percent of the particles less than 2.5 µm were chrysotile asbestos. Three percent of the particles less than 2.5 µm were a fiber that has not been reported before in dust sample analysis. These fibers were composed of calcium, silicon and sulfur.

Characterization Of Particulate Found In Apartments After Destruction Of The World Trade Center

Eric J. Chatfield [1] and John R. Kominsky [2]

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Immediately following the destruction at the World Trade Center on 11 September 2001, the EPA and OSHA began to monitor the air and soil around the World Trade Center site (Ground Zero) to determine the presence of asbestos, lead, polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and volatile organic compounds.

A lack of information about the environmental safety of their homes soon became of great concern to the 50,000 residents of lower Manhattan surrounding Ground Zero. Residents who were allowed to remain in their homes did not know if they were at risk from contamination in their homes, and residents who had been told to stay out of their homes did not know when it would be safe to return. Schools and businesses shared similar concerns.

A "Ground Zero" Elected Officials Task Force was formed to respond to the concerns of the residents. On 15 September 2001, the Task Force requested that an independent environmental assessment of residences be conducted to provide residents with information and reassurance. A meeting with representatives of the Task Force was held on 17 September 2001. The Task Force representatives specified areas around Ground Zero that were of greatest concern.

A small-scale monitoring survey of two residential buildings was conducted. One of the buildings was on Warren Street four blocks north of Ground Zero, and the second building was on South End Avenue, close to Ground Zero, to the southwest of the World Trade Center. The Warren Street location was considered to have been exposed to lower concentrations of dust than those at the South End Avenue location. The results from exterior and interior dust and debris samples and from passive air samples collected inside the residences and the conclusions and recommendations will be discussed.

Asbestos In Street-Water Run-Off And Roof Tanks Near The WTC Disaster

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Two water samples of street-water run-off were collected from storm sewer outfalls over the Hudson River after the World Trade Center (WTC) disaster of September 11. The first sample was collected on September 14 during the first post-disaster rainfall. Particulate loading was extremely high, 7.4 g/L, presumably debris from the nearby collapsed WTC. Approximately 0.5% of this debris was chrysotile asbestos. Long-fiber (>10 um) chrysotile was present in the water at a concentration of 10,000 MFL. Concentration of short-fiber (>0.5 um) was more than 100,000 MFL. Analysis of a second sample collected after a smaller rainfall on September 22 revealed a reduced particulate loading of 0.05 g/L and long-fiber and short-fiber chrysotile concentrations of 55 MFL and 1000 MFL, respectively. In addition, water samples from four rooftop storage tanks were collected on September 17 near the WTC. Asbestos was detected in only one sample, at a concentration of 0.2 MFL.

Inorganic Geochemistry Of Dusts Deposited In Lower Manhattan After The September 11, 2001, World Trade Center Collapse

Geoffrey S. Plumlee, Philip L.Hageman, Paul J. Lamothe, Stephen A. Wilson, Joseph Taggart, Gregg A. Swayze, Todd M. Hoefen, Peter Theodorakos, Monique Adams, Gregory P. Meeker, Stephen J. Sutley, and Roger N. Clark, U.S. Geological Survey, MS 964 Denver Federal Center, Denver, CO, 80225

As part of an environmental study of the World Trade Center (WTC) area after the attacks of September 11, 2001 (Clark et al., 2001; http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-01-0429/), we characterized the inorganic geochemistry of dusts deposited in lower Manhattan by the WTC building collapse. We analyzed the chemistry of dust sweep samples collected within the first two weeks after September 11, 2001, from 2 indoor and 15 outdoor localities around the WTC in lower Manhattan. Most results of this work were released via the web to WTC emergency response personnel on September 27, 2001.

Silicon, calcium, sulfur, magnesium, aluminum, iron, and carbon (both organic and inorganic) are the predominant elemental components of the dust deposits, and result from the chemical contributions of glass fibers, concrete, gypsum wallboard, metals, paper, and other materials used in building construction or contained within the buildings. Trace-element compositions (zinc – up to 3000 parts per million, ppm; barium, lead, copper, chromium – several hundred ppm; molybdenum, antimony, and titanium – tens of ppm or less) of the dusts reflect contributions from a wide variety of materials such as paints, lighting, electrical wiring, piping, computer equipment, and other electronics. We also subjected the dust samples to water leach tests (1 part by mass dust added to 20 parts by mass deionized water, the mixture shaken for 5 minutes, and the leachate filtered to 0.45 µm and analyzed). The dusts produced quite alkaline leachates due to rapid partial dissolution of concrete and gypsum particles. Indoor dust samples generated higher pH levels (11.8-12.1) than outdoor dust samples (8.2-10.4), indicating that indoor dusts are substantially more alkaline and reactive than outdoor dusts that have reacted with rainfall or other waters. Indoor dust samples also have greater proportions of leachable aluminum and some other metals than outdoor dust samples. Major dissolved metals and metalloids in leachate solutions include aluminum, chromium, antimony, molybdenum, and barium (multiple tens to hundreds of ppb), and titanium, zinc, lead, and copper (several tens of ppb). Dissolved mercury concentrations in leachate solutions from indoor dust samples (130 parts per trillion) are high compared to mercury concentrations measured in many types of environmental water samples. Results of the leach tests indicate that: 1) Continued monitoring of water quality around lower Manhattan is warranted during the course of cleanup, due to potential leaching of metals and alkalinity from the dusts and debris by rainfall or waters used to fight fires and clean streets; 2) Disposal of the WTC dusts and debris should be done with appropriate measures to prevent leaching of metals into ground waters, and; 3) Cleanup of dusts and debris should be done with appropriate respiratory protection to prevent possible inhalation of alkaline material with potentially bioavailable heavy metals and metalloids.

The Protocol For Assessing Asbestos-Related Risk: A Status Report

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In 1999 a draft protocol for assessing asbestos-related risks (along with a companion technical background document) was developed and submitted to the U.S. Environmental Protection Agency (Berman and Crump 1999a and b). The new protocol differs from traditional methods for assessing asbestos-related risks in that it incorporates use of a new exposure index for asbestos (which defines the sizes and shapes of structures to be counted when characterizing exposure) along with dose-response factors that are specifically adjusted (matched) for use with the new exposure index. In general, the fibers included in the new exposure index are longer and thinner than those counted in support of traditional risk assessment methods.

Over the past two years, additional analyses of the supporting epidemiological studies were conducted (including an analysis of the time-dependence of disease incidence) and the critical review of the broader literature was updated to incorporate the most recent several years of relevant in-vivo and in-vitro studies. Although minor refinements to the recommended dose-response factors for asbestos were developed based on the new work, in general, the approach recommended in the 1999 protocol appears sound and appears to provide better (more precise) risk estimates than traditional approaches. Results from the new work have been incorporated into a revised background document to the protocol, which was submitted to EPA this past September. In this talk, results from the latest analyses and literature review will be presented along with a discussion of their implications.

Mineralogical And Geochemical Function On The Health Effects Of Asbestos Mineral Dusts: Insights From A Comparison Of 24 Asbestos Toxicological Standards.

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It is well known that exposure to asbestiform mineral dust is associated with lung diseases such as asbestosis, malignant mesothelioma, and bronchogenic carcinoma. Past attention focused primarily on human exposure and health effects of commercial asbestos. In recent years, there has been renewed recognition of the potential deleterious health effects of asbestos that may occur as accessory minerals in rocks (e.g. serpentinite, a common rock in the US) and in some mineral commodities used in consumer products (e.g. vermiculite or talc). Within the past decades, many in vitro and in vivo studies have shown asbestos to be cytotoxic and mutagenic, yet the mechanisms responsible have escaped identification. It is believed that asbestos-related diseases may be a result of two mechanisms, mechanical and intracellular. Evidence in the literature indicates that the potential for the asbestiform minerals to elicit one or both of these mechanisms may be based on the mineral's mineralogy, size, shape, chemistry, elemental speciation, and electral properties. However, contradictory evidence can also be found in the literature about the specific mechanism of toxicity attributed to specific asbestiform minerals. Thus, the mechanistic questions can be best answered through increased collaborative research between the geochemistry and health-related communities.

One key step in the collaborative research process is the mineralogical and geochemical characterization of individual asbestos standards previously used in toxicological studies. Thus, the USGS has analyzed 5 sets of asbestos standards (standard sets: 5 amosites, 4 anthophyllites, 6 chrysotiles, 5 crocidolites, 4 tremolites). Chemical analyses indicate that elemental content varies between the asbestos minerals of the same mineral sets. X-ray diffraction, scanning electron microscopy and x-ray microanalysis also indicate differences in asbestos habit (crystal shape, cleavage pattern) and the presence of other minerals as contaminants between different asbestos standards and within the sets of asbestos standards. Linked geochemical solubility studies in simulated lung fluids and toxicity studies utilizing each group of standards are in progress. These variations between the asbestos standards, or those within the sets of the same asbestiform mineral, may be responsible for conflicting toxicological results, ultimately inhibiting mechanistic identification.

Health Testing at Ground Zero, New York City

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After the World Trade Center catastrophe people were concerned with the air quality at ground zero and inside the buildings around ground zero. We received requests from building owners concerned health impact of the air and the air quality inside the buildings around ground zero to test the air and determine whether it was acceptable for human occupancy. The technical basis and decision making process for determining which substances to select for testing, and the sampling protocol for testing in building spaces, at the World Trade Center catastrophe will be discussed. Determining which health based guidelines or standards are appropriate under the WTC conditions will be discussed. Some of the findings of sampling in the buildings near the World Trade Center catastrophe will be presented.

Microanalysis And Materials Characterization Of Dusts Generated By The World Trade Center Collapse

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Thirty-six sweep samples of dusts deposited in lower Manhattan by the September 11, 2001, collapse of the World Trade Center (WTC) towers were analyzed by scanning electron microscopy (SEM), energy dispersive and wavelength dispersive spectroscopy (EDS, WDS) and x-ray diffraction (XRD) at the USGS analytical Laboratories in Denver. The dust samples were collected from various surfaces (mostly outdoor) on September 17^{th} -18^{th}. Two of the samples were collected indoors and had not been exposed to rain prior to collection.

XRD analyses indicate that most of the samples contain varying amounts of crystalline quartz, gypsum, calcite, anhydrite and amorphous material. Other phases identified by XRD in small amounts include: muscovite, feldspar, magnesiohornblende, lizardite, dolomite, bassanite, illite, portlandite, larnite, polymorphs of calcium silicates, possible chrysotile, and others. All of these phases can be components of the building dry wall material, concrete, and/or insulation.

SEM, EDS and WDS analyses were performed on unprocessed dust samples, primarily to look for the presence of asbestos and phases containing heavy, or potentially toxic metals. Predominant components of the dusts, as seen by SEM, include glass fibers (which are x-ray amorphous, and occur in levels as high as 40 by volume), concrete phases, and gypsum. Amphibole asbestos was not detected in any of the dust samples. However, trace amounts (generally < 1wt.% by XRD) of chrysotile asbestos have been identified in most of the samples. A large variety of other materials are present at trace levels including, vermiculite (or hydrobiotite), particles enriched in Fe, Zn, Pb, Sr, Bi, Cu and other metals, and unidentified organic materials compatible with wood, paper, etc. The chemical composition of the majority of glass fibers (and glass spheres) in all samples is consistent with slag wool (Nomenclature Committee of TIMA Inc., 1991), however glass fibers with other compositions are present.

SEM and EDS analysis of material coating a steel beam from the WTC debris indicates that chrysotile asbestos is present at levels possibly as high as 20% by volume. This material also contains abundant glass fibers.

Libby…A Historical Perspective

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On November 27, 1928 Joseph A. Babor and William L. Estabrooke of Yonkers, NY were awarded patent number 1,693,015 for the exfoliated vermiculite called Zonolite. Although initially rejected by the patent office, the applicants prevailed after pointing out that Libby Zonolite is unique, "friable, loose and flaky." The Montana State Board of Health, Division of Disease Control conducted inspections in 1944 and 1956. Aided by air sampling (11.6 – 83.0 million particles per cubic foot (mppcf)) and surface dust sampling (8 – 21% asbestos) they established a hazardous condition at the plant.

By 1960, Zonolite was used in numerous building products, but a mountain of it remained in Libby. Its use as an animal feed additive and human food additive was seriously investigated. The Zonolite bread recipe calls for one and one-half cups of "food grade" Zonolite resulting in two small loaves. All weather skiing on vermiculite was tried in 1964, but "the clinging nature of the vermiculite to exposed skin areas could be a nuisance and certainly an eye irritant." Throughout the 1970's the coarse mill tailings were donated to Libby High School for their athletic track surface. In 1981, air sampling on "test runners" found 0.14 fibers per cubic centimeter (f/cc) for the leader and 0.22 f/cc for the follower. The company representative recommended a dust suppressant or binder for the track surface.

Sampling And Analysis Of Vermiculite-Containing Consumer Products For Asbestos Contamination

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Sampling and analysis of vermiculite-containing consumer products was conducted to evaluate potential asbestos exposure from the handling of these materials. During an initial study, a total of 34 vermiculite-based lawn and garden products, representing a broad range of product types and brands, were purchased from retail stores in 9 metropolitan locations throughout the United States. In addition, 4 bags of chemical packaging vermiculite were collected. Bulk samples of the products were analyzed using polarized light microscopy (PLM) and transmission electron microscopy (TEM). Based on the TEM results, asbestos was detected in 15 of the 38 products and was quantifiable in 5 products at concentrations ranging from 0.13 to 0.70%. Air samples (personal and stationary) were collected during simulated use of 7 of these products, and analyzed using phase contrast microscopy (PCM) and TEM. Indoor product use was simulated in a containment unit that was constructed to represent a homeowner's garage or small greenhouse. Based on TEM, actinolite asbestos was detected at a maximum concentration of 0.75 s/cc in personal air samples. In a follow up study, 10 vermiculite insulation products were collected. Bulk analyses by PLM and TEM indicated that half of these products had detectable levels of asbestos, but that asbestos could be quantified (0.13%) in only one sample by TEM. Air samples were also collected during simulated residential activities (i.e., installing vermiculite insulation) in a containment unit constructed to represent an attic, and analyzed by PCM and TEM. Actinolite asbestos was observed in personal samples at a maximum concentration of 3.3 s/cc by TEM. Vermiculite insulation samples from occupied Vermont homes have also been analyzed, and attic insulation studies are continuing in an unoccupied house in Vermont.

Review Of EPA Studies On Consumer Garden Products That Contain Vermiculite

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A detailed review has been conducted of Report EPA 744-R-00-010, entitled "Sampling and Analysis of Consumer Garden Products That Contain Vermiculite", issued in August 2000. The report consists of two sections: one which reports studies by EPA Region 10; and one which reports on a study conducted by EPA Headquarters in Washington, D.C.

Supporting analytical data were obtained for both sections of the report, except for the simulation studies that form part of the study by EPA Headquarters, for which the analytical data continues to be withheld.

Neither study provides any evidence that asbestos is present in current sources of vermiculite, and neither study provides evidence that asbestos fibers are released during manipulation of horticultural products formulated from current sources of vermiculite. The only measurements demonstrating the presence of asbestos in a product and emission of asbestos fibers during manipulation of a product were made using bags of exfoliated vermiculite remaining from past production of vermiculite from the Libby, Montana mine which was closed in 1990.

Strategies For Determination Of Asbestos In Vermiculite

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Amphibole fragments are often associated with vermiculite. The compositions of these amphibole fragments may include some that are consistent with the compositions of regulated asbestos species such as tremolite, actinolite or anthophyllite, or unregulated asbestos species such as richterite/winchite. Amphibole with a composition consistent with one of the asbestos species may be non-asbestiform or asbestos. In vermiculite, the size range of the amphiboles may range from fragments comparable with the size of the vermiculite flakes down to particles visible only by transmission electron microscopy (TEM). For determination of the weight concentration of asbestos in vermiculite, the analytical method must be capable of accommodating a wide range of particle size.

An analytical procedure will be described which permits reliable measurements of the weight concentration of amphibole asbestos in vermiculite. This procedure also permits determination of the number of respirable fibers per unit weight of vermiculite and per unit weight of respirable dust. As for all measurements and analytes, it is never possible to specify that no asbestos is present in any particular vermiculite sample; it can only be stated that, for a particular limit of detection, no asbestos was detected. More extensive examination can always lower the limit of detection.

Optical And Morphological Characterizations Of Amphibole And Amphibole-Asbestos Collected From The Former Vermiculite Mine Near Libby, Montana, U.S.A.

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In October 1999, we collected a suite of three amphiboles samples from the former vermiculite mine near Libby, Montana which represents differing geological settings within the mine: an outcrop sample, a vein sample, and a float sample. A polarizing light microscope (PLM) was used for morphological characterizations of grain mounts and, when equipped with a spindle stage, to determine the refractive induces and 2V, along with the thickness of the samples. The PLM provides a rapid method to distinguish amphibole fragments from amphibole fibers in the lab or field.

Approximately 300 particles from each of the three samples were observed and measured. Based on morphological properties (i.e., splayed ends vs. blunt ends, sharp extinctions vs. wavy extinctions, etc.) all three sample types were composed in almost equal proportions of fibers, fragments, and particles that could not be classed with confidence as either fiber or fragment. The average length and width (in microns) and aspect ratios were: fibers (234, 3.0, 90), fragments (94, 7.0, 22), unclassified (61, 2.3, 22).

Next, size measurements (length, width, and thickness) were made with the aid of the spindle stage, on fifty particles taken from the vein sample. Thirty-one of these samples were fibers with average length, width, and thickness (574, 78, 53 microns, respectively) and aspect ratios for length/width, length/thickness, and width/thickness (11, 16, 1.5, respectively). The average length, width, and thickness of the other nineteen fragments were 518, 62, and 36 microns, respectively, and aspect ratios for length/width, length/thickness, and width/thickness were 11, 22, and 1.9, respectively.

Finally, the refractive indices and 2V were precisely determined for four single crystals from each of the three samples. The refractive indices ranges are: α 1.6177-1.6265, β 1.6305-1.6370, γ 1.6337-1.6417, and 2Vx 100-122°. Ongoing chemical analysis of these samples showed them to vary in composition between winchite and richterite.

Analytical Methods And Quality Assurance In Vermiculite Testing

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The methods that have been previously used for the analysis of the asbestos content of vermiculites are reviewed with discussion of their analytical sensitivities and detection limits for quantification. Proposals are made for validation of qualitative and quantitative methods of vermiculite analysis so that suitable industry standards can be applied to raw materials and products. Proposals are also made for a quality control scheme and for an international quality mark that would be acceptable to users and consumers of vermiculite and vermiculite products.

Recommendations are also made for asbestos identification in industrial minerals together with a recommendation that harmful minerals be controlled by their likely toxicological properties rather than by their nomenclature.

Analysis Of Crayons For Asbestos And Other Fibrous Materials

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Reports of asbestos fibers being found in crayons appeared in the media in the spring of 2000. Nationally accredited laboratories reported conflicting results for the analyses of these materials. Since Research Triangle Institute is active in the development of analytical methods for asbestos and related quality assurance programs, RTI was concerned about the reasons for these conflicting results. RTI has conducted an independent analysis of these materials and has identified fibrous components from the talc used in some crayons as the source of the fibers identified as asbestos. Fibrous materials found include talc, asbestiform anthophyllite, and asbestiform fibers of mixed assemblage (anthophyllite and talc). Findings of the study will be discussed as well as recommendations for improving definitions of fibers identified in these analyses.

Critical Issues In The Identification Of Asbestos - Whatever The Mineral Species

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Considerable controversy has arisen over the last several years related to the identification of amphibole minerals in talc, marble, and other mined commodities and the products produced from these commodities. This controversy spawned governmental investigations and dueling laboratory analyses. The root cause of the controversy is the complicated mineralogy of these "amphiboles" and a laboratory's desire to use cookbook analytical methods instead of sound scientific reasoning. This paper will discuss the mineralogy of these mineraloids and analytical procedures to use for identification. A procedure will be discussed that can be followed for proper mineral identification.

The Health Experience Of Vanderbilt Talc

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The characterization of minor but observable fibrous components in Vanderbilt talc is a focus topic of the conference. Deferring that discussion to others, this paper focuses upon the mortality and morbidity experience of those most exposed to these fibrous components – Vanderbilt talc miners and millers in upstate New York. The purpose of this overview is to lend perspective to the mineral nomenclature and analytical methodology issues associated with these fibers.

Vanderbilt talc workers are among the most studied in the world. Since this talc facility opened in 1948, six lung cancer mortality studies have been published specifically covering this operation. Since the early 1950's the pulmonary status of these workers has also been routinely evaluated through an active medical surveillance program and extensive dust exposure data has been obtained. This unique industrial grade talc (in whole and in part) has been tested against asbestos in animal and cell studies as well. Cancer studies involving users of this talc also exist. Unlike many mineral dust exposures, a great deal is actually known about the health risks associated with this talc.

The actual health experience of these talc workers and the results of experimental testing stands in stark contrast to sensationalized new stories and popular belief. The experience does not support an asbestos type risk. The health experience of Vanderbilt talc workers, in fact, appears better than that seen in most mining populations (including that of platy – cosmetic grade talc miners in Vermont).

The implications of these findings will be discussed in regard to the relevance of this talc as a public menace and the influence risk perception (real or imagined) might have on asbestos analytical protocols and mineral nomenclature.

The Optical Properties And Chemical Composition Of Fibrous Talc

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Although most commonly found in a platy habit, talc may also form fibers, which in some cases are asbestiform. This habit of talc is referred to as fibrous talc. Fibrous talc may be composed of only the mineral talc, but the term has also been used in the mineralogical literature to describe talc intergrown with amphibole and other silicates. Talc and Mg end member chain silicates are structurally similar and when intergrown exhibit optical properties, including indices of refraction, birefringence and extinction angle, that are intermediate between talc and the intergrown mineral. This paper will describe the variation in optical properties, chemical composition and habit of fibrous talc from Montana, Texas and New York.

Reconstructing A Century Of Airborne Asbestos Concentrations In The Talc-Mining Region Of New York State: Tales From The Muck

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Paleolimnology, analytical electron microscopy, and empirical aerosol-sediment modeling were combined to provide the first measurements of airborne asbestos concentrations prior to the 1970s. Pb concentrations and respirable aerosol mass concentrations in air and sediments yielded collection efficiencies of ~ 3×10^9 cm^3 of air per g lake sediment. Airborne concentrations of chrysotile reconstructed from control lake sediments followed chrysotile's usage during the 20^{th} century, with highest concentrations mid-century (~0.1 fibers/cm^3), decreasing in the last quarter century. Less common amphibole asbestos recovered in study lake sediments were consistent with ores from talc mines located ~8 km upwind of that lake. Calculated airborne concentrations of anthophyllite asbestos increased from 0.004 to 0.026 fibers/cm^3 from 1847 to 1995. These airborne anthophyllite asbestos concentrations during the ~100-year period of talc mining correlated well ($r^2 = 0.84$, $p = 0.001$) with annual production of local talc, and were much higher ($p = 0.004$) than concurrent concentrations at a control lake located upwind of the mines and mills.

Geologic Origins Of The "Transitional Fibers" In Fibrous Talc Deposits

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Much of the debate in determining the amphibole asbestos content in talc deposits focuses on "transitional fibers", sometimes termed "intermediate fibers", because they are composed of fibrous talc and amphibole in various proportions and are difficult to categorize. "Transitional fibers" typically have mineral compositions, X-ray diffraction patterns, and optical and chemical values, which range between the published values for ideal talc or amphibole, or show dual patterns. These fibers are "caught in the act" of transformation, and form by partial, pseudomorphic replacement of fibrous amphibole with talc and (or) by the microscopic intergrowth of amphibole with talc.

Transitional fibers are formed by metasomatism resulting from regional or contact metamorphism. The large U.S. talc deposits described in the literature as metamorphic in origin consistently contain amphiboles (most commonly anthophyllite or tremolite), often as major components. In contrast, descriptions of hydrothermal talc deposits consistently lack mention of amphiboles, fibrous or otherwise. Host protolith is not the primary control on the presence or absence of amphiboles and transitional fibers. A stress fabric, imposed by regional or contact metamorphism, apparently encourages fibrous amphibole growth, which involves early formation of acicular amphiboles and subsequent partial to complete replacement by talc.

Mineralogy And Experimental Animal Studies Of Tremolitic Talc

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The nomenclature of asbestiform talc is not specific enough to define a class of carcinogens. The proper nomenclature should be fibrous talc and transitionals (an intergrowth of talc and anthophyllite). Microscopic analysis indicates the fibrous particulates in talc are not surrogates for asbestos. This fact is further substantiated by the results of several animal studies, which indicate significant differences in that fibrous talc and transitionals lack the carcinogenic potency of asbestos. An understanding of the mineralogy of tremolitic talc is required to evaluate whether this assemblage of minerals can cause cancer in humans or experimental animals. Tremolitic talc contains three phases – anthophyllite, tremolite and serpentine – which can exist as asbestos or non-asbestos minerals. The two-amphibole minerals occur more commonly in nature in a non-asbestos habit, although each can occur as asbestos. The characteristics of each phase was examined and compared to fibrous talc and transitionals using polarized light microscopy, continuous scan x-ray diffraction, electron diffraction and analytical transmission electron microscopy. The results of these analyzes will be used to clarify the literature describing this assemblage of mineral.

Analyzing Non-Asbestos Asbestiform Minerals

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Over the last two years, events in the industrial hygiene community have spotlighted the need to apply better analytical techniques to the analysis of asbestos samples. Since the early 80's the focus of asbestos analytical laboratories has been on commercial asbestos materials, mostly in the removal business. Commercially, only three of the many asbestiform minerals are significantly represented. Analytical shortcuts used in the analysis of asbestos, while appropriate for known asbestos samples, may not be sufficiently accurate to identify non-asbestos minerals. This is significant because only chrysotile, Amosite, crocidolite, anthophyllite, tremolite and actinolite are included in the definition of asbestos used in regulations. As other minerals appear in health related investigations, it is important to correctly identify the mineral involved. This discussion presents the sufficient and necessary tests and instrumental conditions to conduct successful mineralogical identifications.

Limitations Of Methods For Determination Of Asbestos In Talc

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Talc has been used as one of the ingredients in the formulation of childrens' crayons. In some crayons, a substantial amount of non-asbestiform tremolite is present as a contaminant in the particular talc used. This talc also contains long, thin fibers that have crystallographic structures consisting of various mixtures of the talc and anthophyllite structures, over the whole range from pure talc to pure anthophyllite. These "transitional fibers" pose a serious problem for the asbestos analyst; some laboratories have classified them as anthophyllite, some have classified them as talc, and others have classified them as talc-anthophyllite intermediate or "transitional fibers". Transmission electron microscopy (TEM) and energy dispersive x-ray analysis (EDXA) have been applied in attempts to discriminate "transitional fibers" from fibers of anthophyllite. The differences in chemical composition between talc and anthophyllite, as measured by EDXA, are insufficient to provide reliable discrimination between the two, much less to classify the fiber as some intermediate mixture of the two minerals. Electron diffraction provides the only means in the TEM by which fibers of talc and anthophyllite can be reliably discriminated, but this can be done only if the fibers are sufficiently thin. For mass determination, the thicker fibers contribute a greater mass. Unfortunately, most of the mass of talc fibers, "transitional fibers" and anthophyllite fibers in a talc sample is present as large fibers that are too thick for measurements by electron diffraction in a 100 kV TEM. This means that the TEM cannot be used to reliably determine the mass concentration of anthophyllite in talc.

It was concluded that polarized light microscopy (PLM) and dispersion staining provided the optimum approach to discriminating between "transitional fibers" and anthophyllite in talc. The weight percent of anthophyllite in a talc sample can be conveniently determined by size-selective point counting under dispersion staining illumination conditions.

Optical Characteristics And Mineralogy Of "Environmental" Amphibole Asbestos

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Two general types of amphibole asbestos can be recognized depending upon the source; commercial sources, and natural sources associated with other mineral products or found in the general environment, hereafter referred to as environmental asbestos. There are significant differences between commercial and environmental amphibole asbestos that can cause difficulties in identification and quantitative analysis. The large deposits of amphibole asbestos that have been commercially exploited are restricted to a few amphibole types that have relatively little chemical variability. Environmental amphibole asbestos comprises all the amphiboles, even those that have not been specified in the regulatory nomenclature. There are also differences in the degree of development of the asbestiform habit between commercial and environmental sources, which can affect the optical properties, including extinction characteristics and refractive indices.

Tremolite Analysis Of Chrysotile Containing Friction And Gasket / Packing Products

W. E. Longo, W. Egeland, R. Hatfield, R. Stapleton and J. Hubbard, Materials Analytical Services, Inc. Suwanee, Georgia

There has been an ongoing debate concerning the presence or absence of tremolite asbestos fibers in chrysotile containing friction, sheet gasket and packing products. Even though it has been well characterized that chrysotile and serpentinite rocks can be contaminated with small amounts of tremolite, it has been suggested that during the milling and grinding process there is enough differentiation to completely remove the tremolite contaminate from the chrysotile used in these products. In fact, in this laboratory, routine PLM and TEM analysis of bulk samples of gaskets and brake shoes have not been successful in detecting tremolite in these products. The question becomes do these products only contain pure chrysotile or is it a detection limit issue for these two methods? Others have described dissolution techniques for concentrating tremolite in raw or processed chrysotile.[1, 2] The method uses an acid and basic wash technique to dissolve the chrysotile while leaving the tremolite behind. However, this method, as best we can determine, has never been used on finished products. This study applied this method to certain chrysotile containing sheet gaskets, packing and friction products and found that they do contain tremolite asbestos. The procedure uses a muffle furnace treatment of 600°C to reduce the crystal structure of the chrysotile and to remove all organic material. The concentrate is then treated with boiling H_2SO_4 followed by a treatment of boiling NaOH which removes most of the chrysotile while leaving the tremolite in the residue. The chemistry and crystalline structure of the tremolite is not affected by this procedure as determined by both EDXA and SAED.

[1] A.A. Hodgson, Asbestos International Association, November 22, 1984.
[2] Addison & Davis, "Analysis of Amphibole Asbestos in Chrysotile and Other Minerals," Ann. Occup. Hyg, Vol. 34, pp. 159-175, 1990.

Revisiting Refractive Index Measurement Methods

Peter M. Cooke, MICA, 5807 Maplewood Avenue, Chicago, IL 60659

In laboratories specializing in the identification of asbestiform minerals using a polarized light microscope and the immersion method, refractive indices are most commonly determined by observation of central stop dispersion staining colors. This presentation evaluates this and alternate means for refractive index measurement by comparing the instrumentation, techniques, advantages and limitations of the use of central and annular stop dispersion staining, dispersion colors, Becke lines, oblique illumination, phase contrast dispersion, and critical darkfield dispersion staining.

Asbestos Impurities In Olivines

G.Burdett, Health and Safety Laboratory, Broad lane, Sheffield , S3 7HQ. U.K.

Asbestos minerals may be formed by the hydrothermal alteration of ultramafic rocks, which consist mainly of Mg, Fe - silicates such as olivine and pyroxene. The type, grade and amount of asbestos formed will depend on the distribution of pre-existing cracks, the composition of the hydrothermal solution and the pressure and temperature regime in and around the host rock. The olivines are a series of magnesium-iron silicates with continuous solid solution from forsterite (Mg_2SiO_4) to fayalite (Fe_2SiO_4); typical natural olivines have compositions towards the Mg-rich end of the series which suggests that chrysotile and anthophyllite asbestos are most likely to be formed.

This presentation gives the results of analyses of material produced from a large commercial source of olivine: using polarised light microscopy (PLM), scanning electron microscopy (SEM) and analytical transmission electron microscopy (TEM). The variation in the asbestos content and relative merits of the analytical methods are evaluated for both screening the material for asbestos and giving sufficient information for an adequate assessment of hazard.

An Assessment Of The Airborne Release Of Asbestos Fibres From Olivine Grits

G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield , S3 7HQ. U.K.

Many millions of tonnes of olivine products are used in industry every year. The highest use is for casting molds and slag conditioner in iron and steel production but it has increasingly found other uses, such as a grit blasting medium. Olivine can be contaminated with asbestos and each use will present a different level of risk.

This presentation gives the results from bench scale dustiness testing of olivine grits to evaluate the likely airborne concentrations that may be produced. The mass concentration data from the hazard analysis is compared to the airborne concentrations from the risk analysis. The results suggests that for some uses asbestos contents of below 0.0001% by mass are necessary to reduce the risk sufficiently that it is below accepted workplace limits.

The implications for the current methods of measurement and regulatory requirements are reviewed.

The Quality Of Fiber Count Data Of Slides With Relocatable Fields

T. W.S. Pang, Dept of Chem. Eng & Chemistry, Ryerson Polytechnic University, 350 Victoria Street, Toronto, Ont. Canada M5B 2K3

A simple method has been developed to prepare slides with relocatable fields from asbestos air samples for phase contrast microscopic analysis. The image quality of the fibers is comparable to that of the fibers prepared by the acetone/triacetin method and the dimethyl formamide/ Euparal method. These slides have been shown to be an effective tool to evaluate the accuracy and interlaboratory precision of fiber counts. A new quality control program using these slides is being proposed to control and rectify the intra-counter and inter-counter variability.

Enhancement Of The Quality Of Asbestos Fiber-Counting Analyses By Means Of Certified Reference Slides

M. Harper, University of Alabama at Birmingham, School of Public Health, RPHB 317, 1530 3rd Ave. S, Birmingham, AL 35294-0022, M. E. Beard, Research Triangle Institute, 3040 Cornwallis Rd, PO Box 12194, RTP, NC 27709-2194, J. H. Nelson, 2327 Cavalier Drive, Salt Lake City, Utah 84121

Accurate airborne fiber counts are the basis of many critical hygiene decisions. There are concerns regarding the quality of fiber counting. Proficiency test samples may have standard deviations of greater than 20%, yet these limits are met only with difficulty by many laboratories. An initiative to improve the quality of fiber-counting results is currently underway through the Industrial Hygiene Laboratory Accreditation Committee of the American Industrial Hygiene Association (AIHA-IHLAC). Twelve commercially available asbestos reference slides with relocatable grid areas are being purchased and characterized by six AIHA-accredited laboratories. The six reference laboratory microscopists plus an independent referee will convene to reach agreement over the fibers that meet the regulatory definition of a countable fiber (National Institute of Occupational Health, Method 7300). The slides plus consensus documentation will be made available to AIHA-accreditation site assessors for use in assisting laboratories to resolve any difficulties in meeting the required quality standards. The site-assessor will be able to use the slides to detect and correct errors in both equipment capability and individual microscopists fiber-recognition heuristic. Results are expected by October, 2002. It is expected that these slides will find wider use as laboratory training aids. The IHLAC thanks the AIHA's Technical Development Fund for their assistance with this project.

Polarized Light Microscopy: What Does It Mean For Asbestos?

D. Wayne Berman, Ph.D., Aeolus, Inc., 751 Taft St., Albany, CA 94706

30 environmental samples (soils, sand, or crushed rock containing either naturally occurring asbestos or asbestos-containing product debris) were homogenized, split, and analyzed for asbestos using Polarized Light Microscopy (PLM) and Transmission Electron Microscopy (TEM). A comparison of the results across the paired measurements indicate that PLM does not provide a reliable estimate of asbestos concentrations and further suggests conditions under which PLM will not even provide a reliable indication of the presence of asbestos, particularly amphibole asbestos. Because fourteen of the samples that were included in this evaluation also represent each of paired splits from the field, the variation within each analytical technique could be evaluated as well as the variation across techniques. Many of the samples included in this study contained both chrysotile and amphibole asbestos.

Results from this comparison indicate good within-method precision across TEM duplicates that is consistent with the performance reported for this method (the Superfund Method, Berman and Kolk 1997) in other studies (see, for example, Berman 2000). Because the majority of duplicate pairs analyzed by PLM exhibited either no asbestos or only trace asbestos concentrations, evaluation of within-method performance for PLM was limited.

Regarding between-method comparisons, of 22 samples in which no asbestos was detected by PLM, TEM analysis showed amphibole asbestos in 14 of the samples. Three samples also exhibited chrysotile, when analyzed by TEM. Concentrations of amphibole detected by TEM among the samples showing no asbestos by PLM ranged between 1 $x10^6$ and 2×10^9 s/g, which is virtually identical to the range of concentrations observed by TEM among samples for which amphibole asbestos was detected using PLM (reported up to 3%). Among samples in which amphibole asbestos was detected by PLM, no correlation between the PLM-based and TEM-based concentrations was apparent, even among samples collected within the same environmental matrix.

The situation with chrysotile was similar but not as extreme as that observed for amphibole asbestos. Moreover, some samples collected within the same environmental matrix appear to show gross correlation between PLM-based and TEM-based measurement, but the correlation does not hold across matrices. This suggests that PLM might be used as a surrogate for TEM in limited circumstances as long as chrysotile is the only type of asbestos of interest and as long as PLM results are properly calibrated (correlated) with TEM. Importantly, "false positive" detection of asbestos by PLM was also apparent in a small number of cases and the consequences of such detection must also be addressed when considering the utility of using PLM as a screening tool for environmental asbestos.

The European Method For Measuring Asbestos In Bulk Materials

G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield , S3 7HQ. U.K.

This presentation gives an overview of the work carried out to produce a quantitative method for the analysis of asbestos in bulk materials in the EU. The method was designed to measure the mass concentration of asbestos in a matrix. The following target performance was specified. The method should at the 0.1% asbestos concentration by mass in a bulk sample of grain size less than 2mm obtain a result, which with 90% probability, is correct within a factor of two.

The method was based on a sample preparation method involving: coning and quartering, digesting/concentrating, grinding, sieving and sedimentation followed by a combined polarised light microscopy (PLM) / phase contrast microscopy (PCM) analysis. to identify and size the asbestos fibres. Each parameter was investigated to produce a method which would meet the target specification.

The method was tested in an inter-laboratory round-robin using a variety of laboratories who were both experienced and new to the method.

The advantages and disadvantages of the method are reviewed.

A PLM Method For Quantitative Analysis Of Amphibole Asbestos In Bulk Materials At 0.01 Wt %

Jennifer R. Verkouteren[1] and Ann G. Wylie[2], [1]National Institute of Standards and Technology, [2]University of Maryland

The distribution of mass in most bulk asbestos is concentrated predominantly in the large fibers, particularly large bundles of fibers. Such large bundles will persist, even with moderate mechanical grinding, and can represent most of the mass of the asbestos, although they may be few in number compared with the finer fibers. Measurement of the length and width of the largest fibers in a sample (those that can be observed at low magnification by PLM) can be used to determine the concentration of asbestos in a sample at 0.01 wt %, if the weight of material placed on the microscope slide is known. The proof of the validity of measuring the largest fibers is given, along with specific details of the method.

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STP 1342
Advancements in Environmental Measurement Methods for Asbestos
Editors: M.E. Beard, Consultant
H.L. Rook, NIST

STP 1342 focuses on the latest research advances in measurement methods, monitoring strategies, data interpretation, and quality assurance for asbestos in bulk building materials, as well as ambient, indoor and workplace air, water, and settled dust.

31 peer-reviewed papers are divided into the following sections:

Measurement Methods For Asbestos In Bulk Building Materials examines polarized light microscopy, x-ray diffraction, and transmission electron microscopy (TEM) techniques. The performance and shortcomings of certain of regulatory methods were also discussed.

Measurement Methods For Asbestos In Ambient, Indoor And Workplace Air covers presentations on OSHA, EPA, and ISO methods for monitoring airborne asbestos by either phase contrast microscopy or TEM. It also explores research on technique for determining fiber length/diameter distributions and the depth of penetration of fibers into membrane filters.

Measurement Methods For Asbestos In Water reviews EPA and the American Water Works Association methods for monitoring asbestos in drinking water and research on improved sample preparation techniques.

Measurement Methods For Asbestos In Settled Dust contains controversial material on analytical methods employing TEM developed by ASTM Subcommittee D22.07 for monitoring asbestos in settled dust.

STP 1342 is a useful guide for asbestos consultants, asbestos analytical laboratories, industrial hygienists who specialize in asbestos, building owners and managers, and Federal and State governmental units responsible for asbestos regulations.

425 Pages (1999); Hard Cover
$95 North America; $105 Elsewhere
ISBN 0-80313-2616-6
Stock #: STP 1342

Manual 23
Manual on Asbestos Control: Removal, Management, and the Visual Inspection Process
Author: A.F. Oberta, PE, CIH

Manual 23 guides you through *ASTM Practice for Visual Inspection of Asbestos Abatement Projects* (E 1368), in a way that maximizes your chances for passing the visual inspections by following the correct procedures throughout the abatement project or O&M task.

Seven chapters authored by a nationally-recognized authority on asbestos control include the following:

- History and Concepts of Visual Inspection
- Application to Abatement Projects
- Special Considerations for Abatement Projects
- Application to Operations and Maintenance
- Protective Measures and Safety
- Due Diligence and Litigation
- Future Trends in Visual Inspection.

Note-The manual is thorough in its treatment of the subject matter, but it is not a comprehensive discussion of the hazards of asbestos and means of controlling them. It does not take the place of training manuals for accredited asbestos courses.

71 Pages (1995); Soft Cover
$43 North America; $47 Elsewhere
Stock #: MNL23

STP 1408
Isocyanates: Sampling, Analysis, and Health Effects

Editors: Jacques Lesage, IRSST
Irene DeGraff, Thermo Hypersil—Keystone
Richard Danchik, Consultant

STP 1408 examines the latest data and technology on isocyanates, and features topics ranging from sampling and analysis methods to health effects. Isocyanates are widely used in many industrial processes because of their high activity and affinity to many substances, which lead to polymerization, as well as the properties for the resulting polymers. They are used in the production of adhesives, elastomers, binders, flexible or rigid foams, paints, and lacquers. Because these products are used in a large number of synthesis and processing industries, many workers may be at risk of hazardous exposure. In addition, the various chemical and physical states of mixtures of isocyanate monomers and prepolymers make it difficult to document exposure-related toxicity through valid environmental sampling and analysis methods. Therefore it is of the utmost importance that the knowledge and tools necessary for the safe use of these products be made available to provide protection to the worker and the environment.

11 peer-reviewed papers cover:

Isocyanate Determination in Atmospheres—features new developments in sampling and analysis methods for workplace and environmental monitoring, including direct reading instrumentation, and how they relate to characterization of isocynate monomers and oligomers.

Sampling Strategy and Control—details case studies; global effects; interpretation of test results; control measures; and personal protective equipment designed to meet compliance.

Health Effects—covers toxicology; different routes of exposure, such as skin contact as well as inhalation; biological monitoring; surface contamination determination; evaluation of health effects; and the diagnostics used to detect exposure.

Audience: Researchers, Toxicologists, Industrial Hygienists, safety and health professionals

144 Pages (2002); Soft Cover
$49 North America; $54 Elsewhere
ISBN 0-8031-2879-7
Stock #: STP1408

ASTM Standards on Indoor Air Quality
This unique new ASTM publication contains 28 standards that establish consistent and reliable methods for the sampling and analysis of indoor air and for accurate interpretation of the resulting measurement data. By ensuring accurate and consistent data on indoor air composition, the ultimate goal of creating healthier buildings can be more easily achieved.

This volume is an invaluable technical resource that will assist the indoor air investigator or researcher and those managing air quality in buildings in making sound evaluations of indoor air quality.

306 Pages (1999); Soft Cover
$79 North America; $87 Elsewhere
ISBN 0-8031-2728-6; Stock #: IAQ00

Manual 15
Radon: Prevalence, Measurements, Health Risks, and Control

Editor: Dr. N.L. Nagda

Radon was recognized as a potential public health threat in the United States more than 30 years ago. To understand and effectively deal with radon, one needs to understand the physics of radon, its health effects, measurement techniques and protocols, the extent of its occurrence in the United States, mitigation principles and practices, and legislative and regulatory actions.
Manual 15 addresses these areas and provides a well-rounded look at the radon issue. Ten peer-reviewed chapters include:
• Radon -- A Multifaceted Environmental Problem: An Overview
• Radon and the Natural Environment
• Health Effects of Radon
• Measurement Methods and Instrumentation
• Radon Measurement Protocols
• Geology and Occurrence
• Concentration Patterns
• Radon Control Strategies
• EPA's Strategy to Reduce Risk of Radon
• Current and Future Perspectives.

170 Pages (1994); Soft Cover
$59 North America; $65 Elsewhere
ISBN: 0-8031-2057-5; Stock#:MNL15

The European Method For Measuring Asbestos In Bulk Materials

G. Burdett, Health and Safety Laboratory, Broad Lane, Sheffield , S3 7HQ. U.K.

This presentation gives an overview of the work carried out to produce a quantitative method for the analysis of asbestos in bulk materials in the EU. The method was designed to measure the mass concentration of asbestos in a matrix. The following target performance was specified. The method should at the 0.1% asbestos concentration by mass in a bulk sample of grain size less than 2mm obtain a result, which with 90% probability, is correct within a factor of two.

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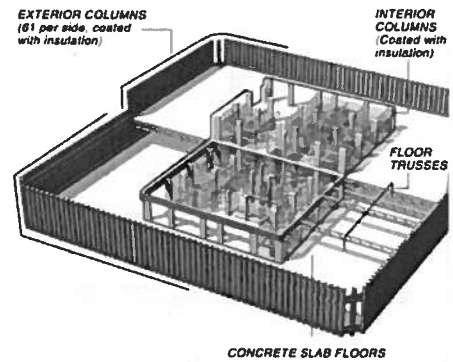
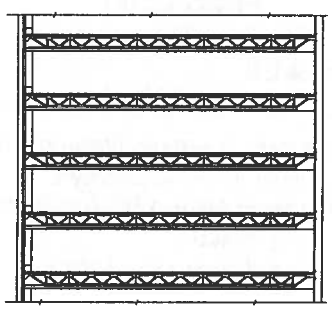
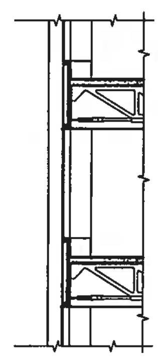
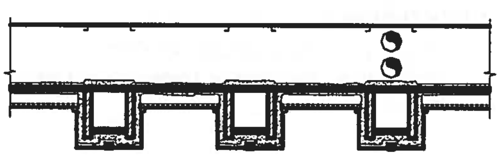
Asbestos in World Trade Center Towers

Roger G. Morse AIA

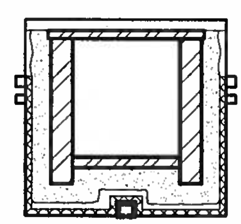


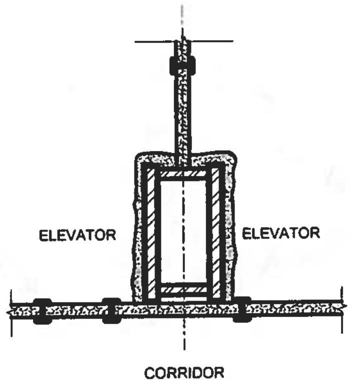






Column Section Below Sill





Dry-spray Fireproofing

- Long span joists
- Trench headers
- Outside face of outside wall,
- Core columns and beams

Dry-spray Fireproofing

- Cafco Blaze-Shield D
- 20% Chrysotile, mineral wool, gypsum, Portland cement
  - Up to 36th floor of tower 1,
  - NE quadrant of 37th floor,
  - 38th floor east side of core
- Cafco Blaze-Shield DCF
  - Balance of tower 1
  - All of tower 2

Hard Coat

- Cafco Mark II
- 80% chrysotile, 20% Portland Cement
- Installed over dry-spray fireproofing
  - On columns in shuttle car shafts Concourse to 44th and 78th floor Skylobbies
  - On ceiling of MER's
  - On ceiling of floors below MER's

Wet-spray Fireproofing

- Connection between joists and outside wall
- Inside face of outside wall
- Over dry-spray on diagonal bracing in MER's

Wet-Spray Fireproofing

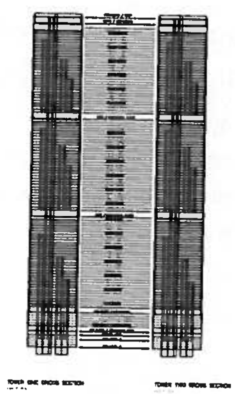
- Mono-Kote 3
- 13% chrysotile, gypsum, vermiculite
  - Probably to 36th floor of Tower 1, but exact extent unknown
- Mono-Kote 4
  - Probably balance of Tower 1
  - Probably all of Tower 2

Significant Dates

- 4/70 – Blaze-Shield D changed to DCF
- 8/25/71 – NYC Ban Passes
- 3/23/71 – Mono-Kote 4 approved by NYC - BSA
- 2/25/72 – NYC Ban Effective

Other ACM

- Floor tile
- Pipe insulation on steam risers
- Lightweight concrete floor slabs?



Towers Survived Impact

- Survived Impact
- Jet Fuel ignited contents
- Steel failed due to heat of fire
- Failure was well before hour rating of protection on steel

Fire Rating of WTC Elements

- Outside walls – 4 Hours
- Columns – 3 or 4 Hours
- Floors 2 hours
- Floor Joists 2 or 3 hours

Time from Impact to Collapse

- Tower 1
  - 1 hour 42 minutes – 5 Seconds
- Tower 2
  - 56 Minutes – 10 Seconds

Fireproofing Thickness on Trusses

- ¾ inches initially
- Retrofit to 1½” started in mid 1990’s
- Retrofit complete in impact area of Tower 1
- Only one floor retrofitted in Tower 2

Fireproofing Thin or Missing

- Long span joists
- Secondary joists
- Joist to wall connection
- Core columns
- Core beams

Field Conditions Causing Problems

- Obstruction from ductwork
- Obstruction from ceiling supports
- Damage from later construction

Damage to Fireproofing During Construction

- Removed by later trades
- Impact damage from later trades
- Damage from maintenance activities
- Damage for renovations

ACM Fireproofing Better than Non-ACM Replacements

- Well developed and proven by years of use
- Less Water in Mix
- More Dense
- More Uniform
- More Cohesive

ASTM E – 119

- ACM Fireproofing subjected to full-scale burn tests
- Non-ACM substitutes not always subjected to full scale burn tests

No ASTM Field Quality Assurance Tests Until 1977

- E-736
  - Adhesion
  - Cohesion
- E-605
  - Thickness
  - Density

No ASTM Suitability Tests Until 1980

- Effect of Deflection (E-759)
- Effect of Impact on Bonding (E-760)
- Compressive Strength (E-761)
- Air Erosion (E-859 – 1982)
- Corrosion (E-937 – 1983)
- Application (E-1523 – 1993)

The World Trade Center Catastrophe: Was the Type of Spray Fire Proofing a Factor in the Collapse of the Twin Towers

Arthur M. Langer and Roger G. Morse

Indoor + Built Environment – 2001;10:350-360

Fireproofing in World Trade Center Towers

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Poestenkill, NY 12140
(518) 283-7671
rgmorse@morse-associates.com

ASBESTOS IN SETTLED DUST CONCENTRATIONS
OUTDOORS IN NEW YORK CITYBEFORE
SEPTEMBER 11, 2001

William M. Ewing, CIH
Technical Director
Compass Environmental, Inc.
Kennesaw, Georgia

First Asbestos Air Pollution Regulations Passed!

The City of New York issued the nation's first regulations designed to control asbestos asbestos pollution during spraying of asbestos-containing fireproofing.

- April 11, 1970

First Asbestos Citation Issued!

The City of New York, Department of Air Resources, served the contractor at the World Trade Center for continuing to spray the dangerous material [asbestos] without complying with the stringent handling of cleanup procedures instituted by the Commissioner's order.

- April 24, 1970

1989 DATA SET

- A steam line explosion in midtown spewed Amosite laden mud over about 12 square blocks
- Thousands of surface samples taken to measure cleanliness of surfaces
- Question raised... What is the normal background level of Amosite

1989 DATA SET (CONT.)

- 5 Buildings selected not in vicinity of steam line explosion, but in the city for surfacing sampling of exterior
- 3 Buildings selected not in vicinity of steam line explosion, but in the city for surface sampling of interior

OUTSIDE SAMPLING

- Plan called for 5 samples from each roof, 5 samples from window sills (increasing height from street level), and 5 samples from building facades (increasing height from street level)
- All samples collected by the microvacuum technique and analyzed by TEM
- Results reported in asbestos structures/cc^2

SURFACE SAMPLE RESULTS - OUTDOORS

Building No.	No. of Samples	Log. Mean	Arith. Mean	Range (s/cm^2)
3700	16	3800	14,000	<400-93,000
3800	16	600	1400	<400-7800
4100	17	930	9100	<400-110,000
4200	15	3200	5700	<500-16,000
4300	15	17,000	33,000	<500-140,000
Totals	79	5100	12,700	<400-140,000

CONCLUSIONS - 1989 DATA

- Only one in over 1,000 structures counted was Amosite; all the rest were chrysotile
- Surface concentrations tend to diminish with height above street level

8

1999 MORSE/LEE SURFACE DUST DATA

- Collected surface dust samples from 9 outdoor ground level locations around the World Trade Center on May 25, 2000
- No asbestos structures found (<45 s/cm^2) in 6 samples using direct preparation (3 samples too heavily loaded for direct preparation analyses)
- Average of 2500 s/cm^2 found in 9 samples using indirect preparation analysis (ASTM 5755)

9

1999 MORSE/LEE AMBIENT AREA AND PERSONAL AIR SAMPLING DATA

- Collected 6 area and 3 personal air samples around the World Trade Center (ground level) on May 25, 2000
- For direct preparation TEM analyses, no asbestos structures reported in 8 samples, 1 structure found in 1 sample (0.0075 s/cc)
- For indirect preparation TEM analyses, an arithmetic mean of 0.14 s/cc found (range of <0.0099 - 0.4882 reported)

10